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EFFECTS OF A SEWAGE SLUDGE COMPOST ON THE CHEMICAL AND PHYSICAL PROPERTIES OF TWO SOILS OF THE TROPICS

G.A. Martínez, V. A. Snyder, J. L. Guzmán and M. A. Vázquez. Dept. of Agronomy and Soils, U.P.R., Mayagüez Campus.

ABSTRACT. The influence of a sewage sludge compost on the chemical and physical properties of an Ultisol and a Mollisol of Puerto Rico were evaluated. Treatments evaluated were: Control (0 compost), 15, 30, 45 and 180 tons/acre of compost. Cassava plants (Manihot esculenta - PI 12902) were planted to ascertain the effects of the compost on crop performance and trace element uptake.

The compost behaved as an acid neutralizing agent, raising the pH of the Ultisol from 4.2 in the control to 7.5 in the uppermost treatments (> 30 tons/acre). Such a significant influence on pH was attributed to the high calcium content of this compost, a reflection of the coagulating agent ($Ca(OH)_2$) employed in the treatment plant. Significant increases were also observed for soil electrical conductivity, phosphorus (Olsen), and levels of EDTA- and DTPA-extractable Fe, Zn, Cu, and Cd. Trace element content remained well below EPA standards (EPA 503 rule). Cassava yield estimates based on 4 month old plants suggest that although beneficial effects may be expected in both soils at moderate rates, excessive loading may be deleterious to crop growth presumably due to overliming or salinity problems.

INTRODUCTION

As most industrialized countries, Puerto Rico is currently facing a capacity crisis of alarming proportions. To prolong the useful lifetime of its landfills, the Government of Puerto Rico is in the process of implementing a series of alternatives geared to reduce landfill loads. Compost production constitutes one of the keystones of the new waste management program. As much as 200,000 Mg of compost/year is expected to be produced by the year 2005, with plans to expand it to 700,000 Mg/year later on. At present, there is only one large scale compost production facility in Puerto Rico, a sewage sludge compost plant located at Arecibo. Agricultural lands represent the most feasible alternative for the utilization of this product. However concerns over the potential introduction of pathogens and contaminants into the human food chain demand a throughout evaluation of the impact of such applications in nature prior to its release to the general community.

The objectives of this project are:

- Characterize the chemical and physical properties of the Arecibo sewage sludge compost.
- Evaluate the effect of compost applications on the chemical and physical properties of tropical soils.
- Determine its effects on contaminant uptake and yield of different crops.
- Identify factors controlling the fate of contaminants in the environment.

MATERIAL AND METHODS

The project started on July 1st, 1996. Initially, an extensive characterization of the physical and chemical properties of the compost was performed. Total C, and N content were determined in a Carlo-Erba analyzer. Total Ca, Mg, K, Al, Fe, and Zn were measured on a Perkin-Elemer 2380 AA spectrophotometer following dry ashing. Trace element contents (i.e., Cd, Cu, Pb, As, Se, Ni, Cr, Cd, and Mo) were determined by wet ashing on an Inductively Coupled Plasma (ICP) Spectrophotometer. Ash content was determined by combustion at 500°C for 6 hours. Organic Carbon content was determined by the Walkley-Black procedure. pH was measured on 2:1 (0.01 N $CaCl_2$ extracts). Electrical conductivity was determined from 3:1 water:solid extracts. "Available" elements were determined on 0.05N EDTA extracts.

Field experiments started on September, 1996 at two research stations. The predominant soils on these farms are an aquic tropudult (Corozal clay), which under natural conditions is highly acidic (pH ≅ 3.7), with high labile Al (≅ 8 cmol(+)/Kg), and a cumulic haplustoll (San Antón), characterized by a slightly alkaline pH (7.6), and no labile Al. Treatments include a control (0 compost), 15, 30, and 60 tons/acre/year of compost. In addition, a treatment consisting of a single application of 180 tons/acre of compost is being evaluated. Each treatment was replicated four times. Cassava plants (Manihot esculenta), PI 12902, were planted on October, 1996. Seventy plants (7 rows of 10 plants) were planted on each plot.

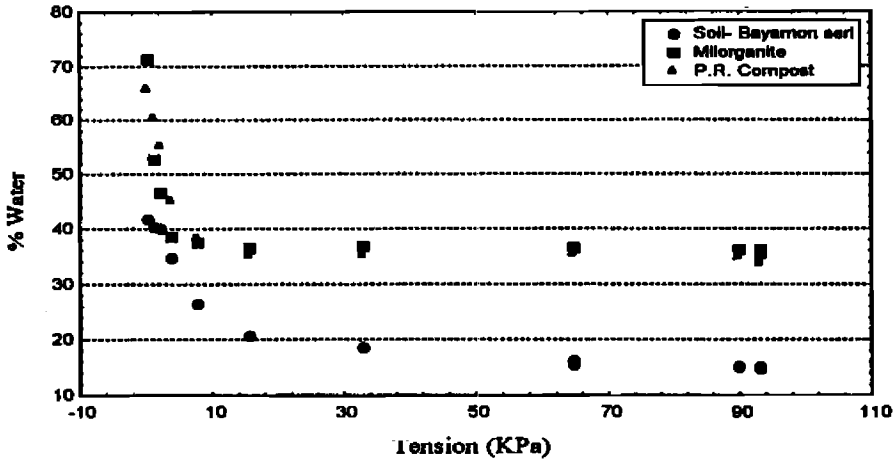

Figure 1: Water retention curve of different systems.

RESULTS AND DISCUSSION

The chemical composition of this particular compost denotes a strong influence from the coagulation agents ($CaC0_3$, $FeCl_3$) employed in the treatment plant (Table 1). As a result, the electrical conductivity of this material is very high, which may cause some problems for plant growth, especially when used as a potting media. Its C/N ratio suggests that this is a stable material ready for use in soils. Although mainly inorganic in character, this material still imparts to the soils some of the benefits of an organic amendment (Figure 1). However, its main attribute is its acid neutralizing capacity (Table 1), and as such, it should be more

valuable for acid soils. Trace element contents are well below USEPA standards (USEPA's 503 rule) which makes is suitable for agricultural purposes.

Table 1: Chemical and Physical properties of the Arecibo Sewage Sludge Compost[1].

Item	Result	EPA limit -503 rule (ceiling concentrations)
Carbon (%)	19.7	
Nitrogen (%)	1.45	
C/N	13.59	
Sulfur (%)	0.11	
Calcium (%)	20.62	
Potassium (%)	0.18	
Magnesium (%)	0.34	
Boron (mg/Kg)	46.3	
Sodium (%)	0.11	
Iron (%)	4.69	
Phosphorus (%)	0.48	
pH[2]	7.63	
Ash %	75.60	
Organic Matter (%)	21	
Moisture Content (%)	21.30	
Electrical Conductivity (dS/m)[3]	14.38	
Electrical Conductivity (dS/m)[4]	43.14	
Total Neutralizing Power (TNP) (expressed as % $CaCO_3$)	110	
Total Fineness Efficiency (TFE) %	68.05	
Bulk Density (g/cc)	0.58	
Particle Density (g/cc)	2.27	
Arsenic (mg/Kg)	3.65	75
Selenium (mg/Kg)	1.29	100
Chromium (mg/Kg)	66.3	3000
Cadmium (mg/Kg)	5.2	85
Lead (mg/Kg)	65.1	840
Nickel (mg/Kg)	31.2	420
Zinc (%)	0.08	0.75
Copper (%)	0.048	0.43

[1] - Compost sample obtained on 10/96 at the Arecibo plant. Total elemental analyses are reported on a dry weight basis (% w/w).

[2] - pH values measured on a 3:1 (0.01N $CaCl_2$: Compost) suspension.

[3] - Electrical Conductivity measured on a 3:1 Water (D.D.): Compost suspension.

[4] - Estimate of a saturated paste extract E.C. (Based on results obtained from aqueous suspension).

The effect of this compost on soil pH corroborates its efficacy as a liming agent (Figure 2). In fact, precautions should be taken to establish a balance between the rates needed to benefit soil structure and those leading to overliming and salinity problems. Some nutrient supplying capacity should also be attributed to this compost as shown by its significant increase in the levels of available phosphorus in soils (Figure 3). This result, frequently observed with organic amendments should be extremely beneficial in highly weathered soils where its P fixing capacity frequently constitutes a limiting crop growing factor. In addition, its capacity to supply trace elements in adequate amounts provides an additional incentive for the utilization of this compost in soils (Figure 4).

However, as previously stated indiscriminate additions of this compost to soils could be detrimental for crop development. The electrical conductivity of the soils significantly increase as a result of compost additions (Figure 5). Although this should be more problematic when used as a potting media, the combination of high salinity and excessive pH could reduce yields (Figure 6) (detrimental effects in the San Antón soil are observed only at the highest application rate). Weed growth constitutes a problem at the highest loading rates.

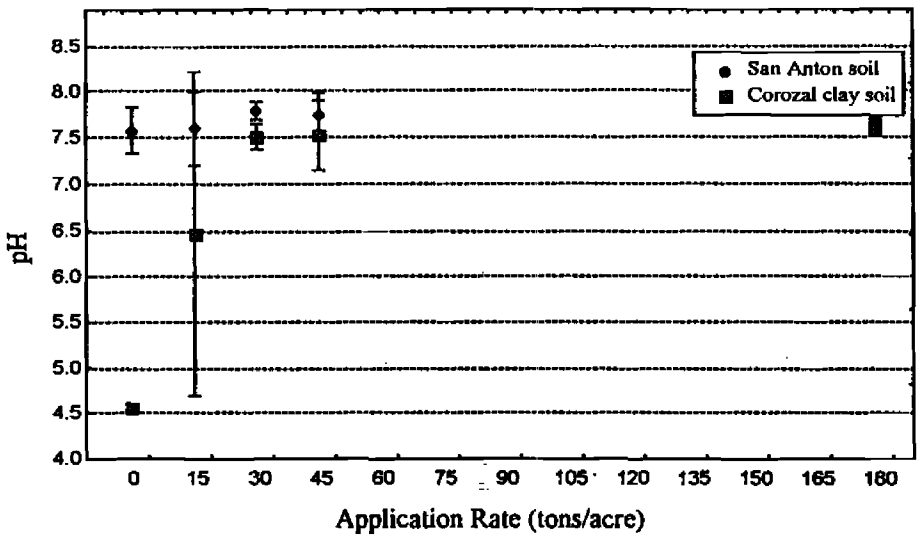

Figure 2: Effects of a sewage sludge compost on soil pH.

CONCLUSIONS

- The sewage sludge compost employed in this study has a strong inorganic character, mainly as a result of the coagulation agents employed in the treatment plant.
- Its acid neutralizing capacity renders it very useful for acid soils, where in addition to raising soil pH it could provide some of the benefits of an organic amendment, as well as some nutrient supplying capacity.
- Precautions should be taken to avoid detrimental effects from elevated salt content as well as from overliming effects.

ACKNOWLEDGMENT

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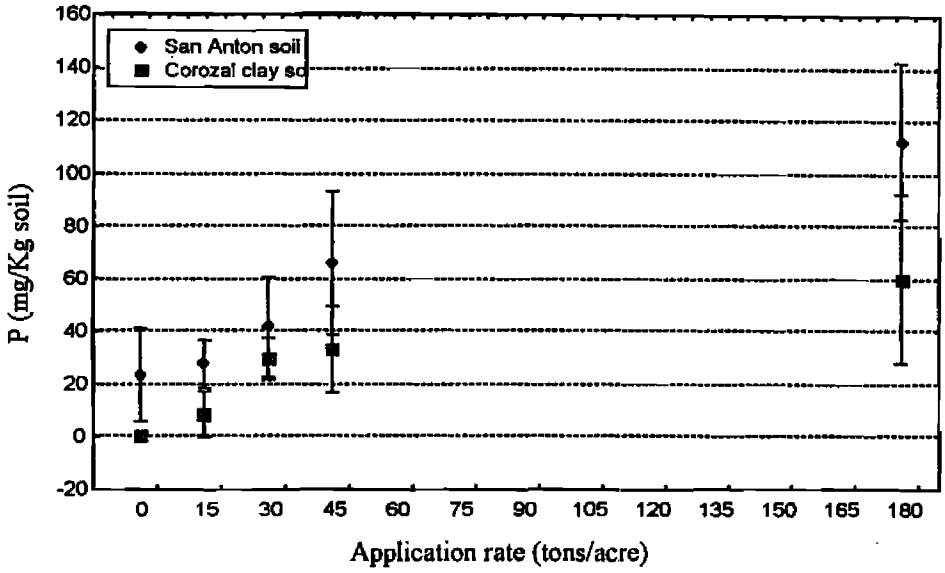

Figure 3: Effects of a sewage sludge compost on soil available (Olsen) phosphorus.

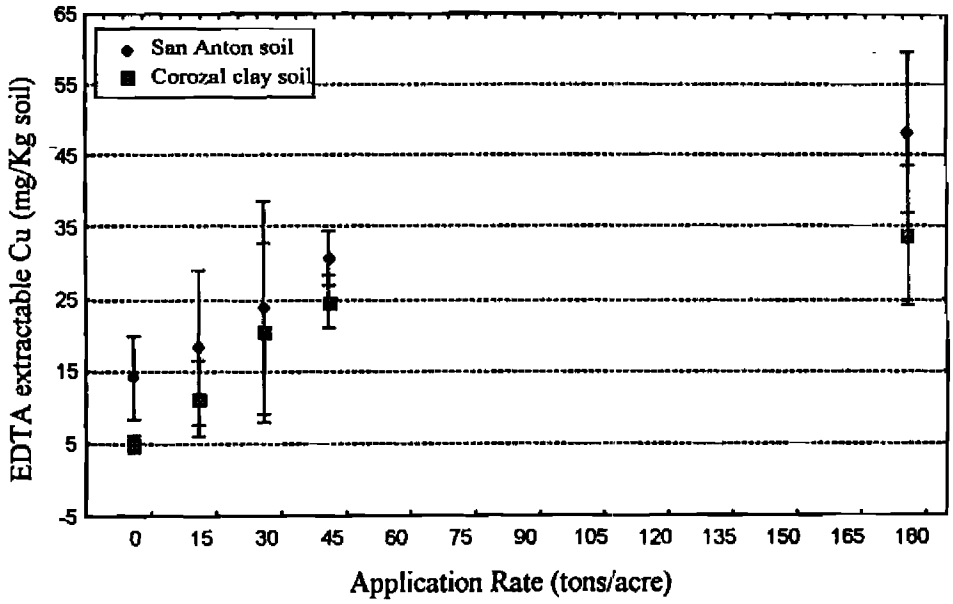

Figure 4: Effects of a sewage sludge compost on EDTA-extractable Cu (one month after treatment application).

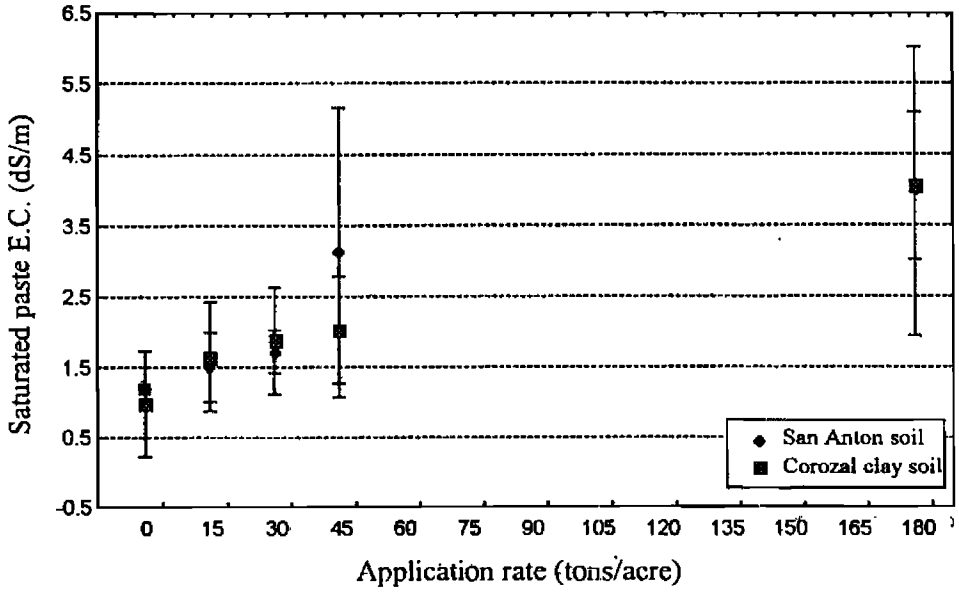

Figure 5: Effects of a sewage sludge compost on the electrical conductivity of two soils (one month after treatment application).

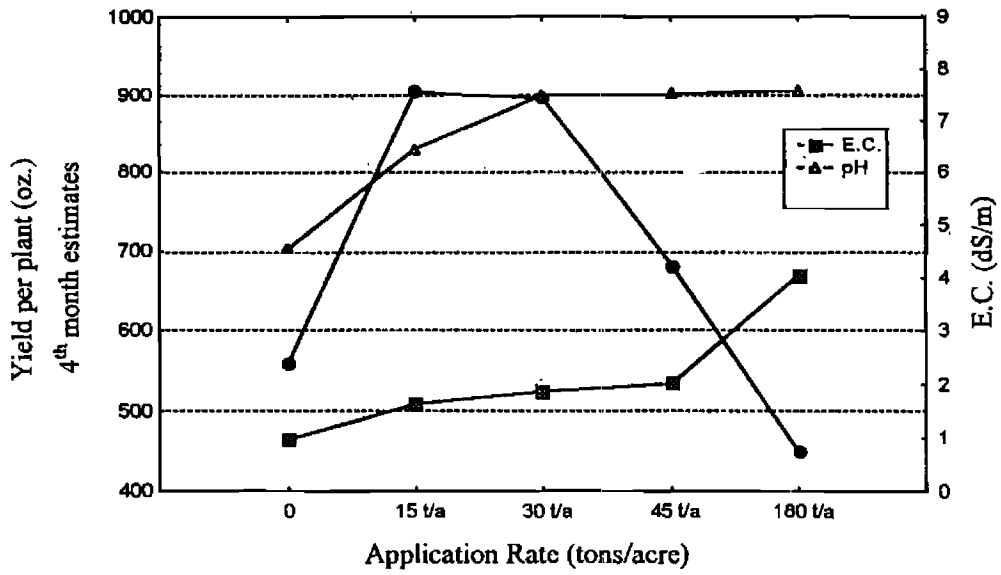

Figure 6: Effects of compost on cassava yield (estimates from 4 month old plants, Corozal clay soil).